Contrast Optimization by Metaheuristic for Inclusion Detection in Nonlinear Ultrasound Imaging

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Context: Nowadays, ultrasound imaging is become an essential tool for diagnosis in industry. This is due to the recent developments of post-processing and pre-processing in nonlinear ultrasound imaging.

Problem to be solved: In flaw detection in industrial media or in inclusion detection in biological tissues, transmission of ultrasound sequences is performed with hypotheses that are mostly not justified. Why exploring media with ultrasound waves at a certain frequency, amplitude, duration, shape without taking into account the explored medium ? Is there another paradigm overpassing this drawback ?

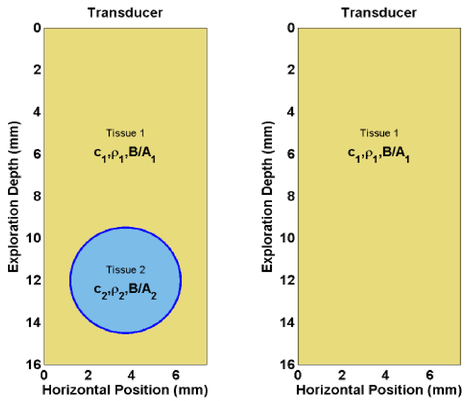

Fig.1: Representation of the 2 media analyzed.

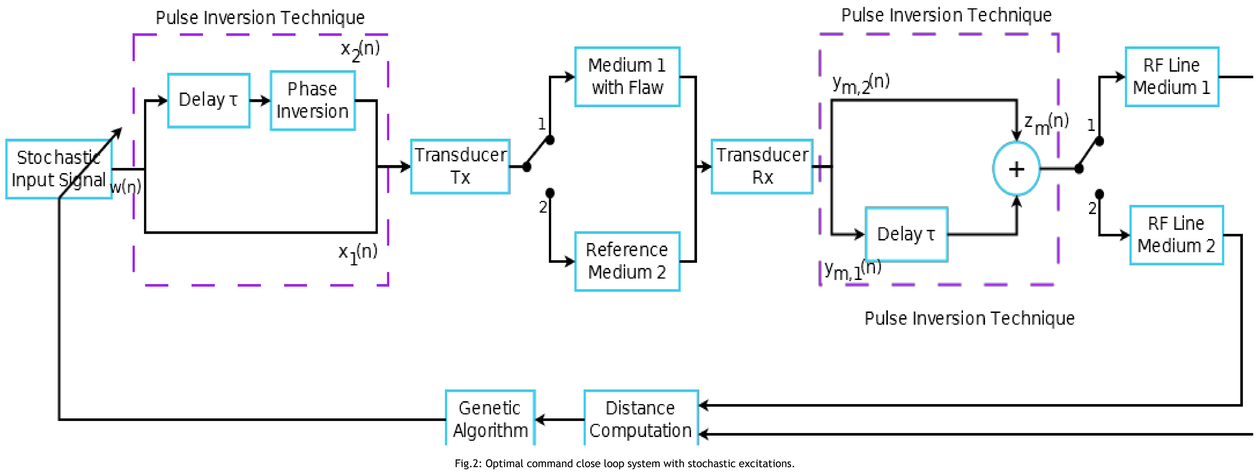

Fig.2: Optimal command close loop system with stochastic excitations.

Proposed solution: The new paradigm that we proposed to take into account the medium but without any a priori information, is to introduce:

1. a feedback in the first steps of the imaging chain allowing an iterative correction of the transmitted waves;
2. a transmission of stochastic waves;
3. a maximization process of the cost function allowing the best discrimination between the reference medium and the tested medium;
4. A meta-heuristic process to accelerate the process convergence.

Simulation Results:

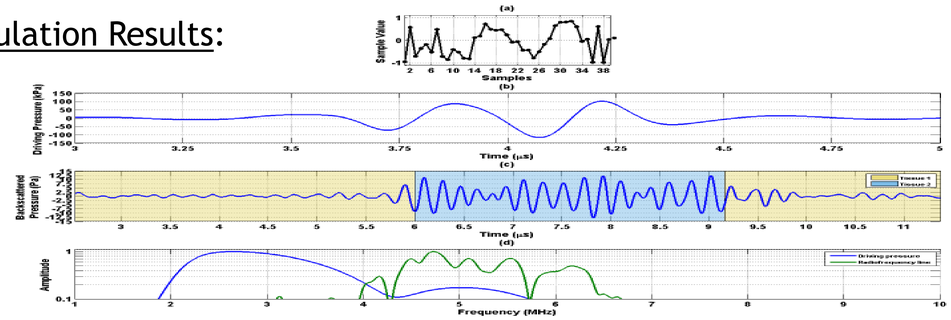

Fig.3 : Time and frequency representations of different signals. a) Optimized stochastic electrical signal before the transducer. b)Optimized stochastic transmitted signal after the transducer. c) The optimized echo with enhanced contrast. d) Spectra of the driving pressure and the echo.

The cost function was an Euclidean distance in a vector space between the cloud corresponding to the reference medium and the cloud corresponding to the tested medium with an inclusion. With less than 30 generation, the distance can be doubled.

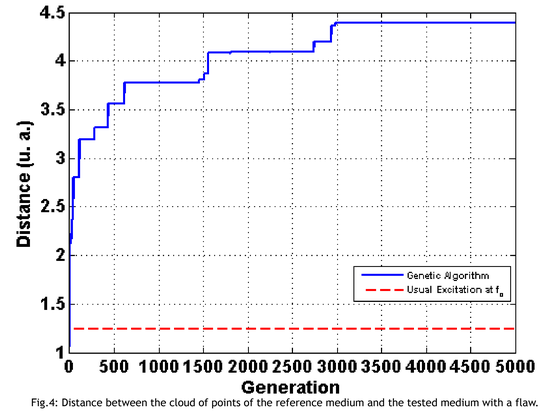

Fig.4: Distance between the cloud of points of the reference medium and the tested medium with a flaw.

The image contrast was improved and the grain image speckle was canceled out.

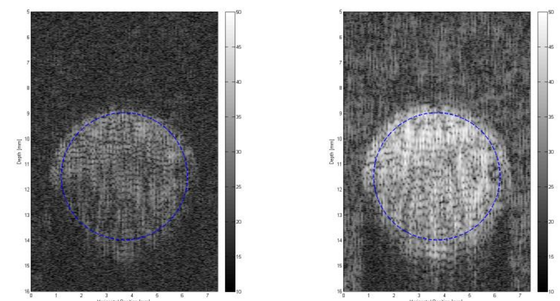

Fig.5: Image with an inclusion obtained with the classical method and with the new method.

Discussions: The optimization highlighted flaws over the surrounding tissue by quadrupling the distance between by the medium and the reference. However to be brought out flaws, the method required a reference medium whose features were close to the surrounding tissue.